Short communication

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Weed management and dynamics of weed seed bank in fennel

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Fennel, *Foeniculum vulgare* Mill. (family Apiaceae), a native of Southern Europe and Mediterranean area, is an important seed spice. Area under *Rabi* direct-seeded fennel is increasing day by day, because of its more profitabbility than other *Rabi* crops like wheat, gram, cumin, mustard *etc.* In spite of this fact, the productivity of *Rabi* fennel is low as compared to its potential yield. The reason for low productivity is lack of ideal agronomic practices and knowledge regarding use and economic importance of fennel besides unavailability of appropriate production technologies. Farmers pay reasonable attention to cultivation, especially in respect of seedbed preparation, manuring and irrigation, however not careful about weed control aspect which remains one of the constraints in boosting up the production.

Therefore, it is essential to find out an appropriate and economical method of weed control to keep fennel fields weed free at the critical stages of crop-weed competition. Initial slow growth of fennel leads to severe weed crop competition and reduces growth, as well as yield as high as 91.4% (Mali and Suwalka 1987).

A field experiment was conducted at Instructional Farm, Junagadh Agricultural University, Junagadh (Gujarat) during *Rabi* season of 2011-12. The experiment was laid ant in RBD with three replications. The soil of experimental field was clayey in texture, slightly alkaline in reaction (pH 8.0 and EC 0.56 dS/m), low in available N (238 kg/ha), medium in available P (36.8 kg/ha) and K (221 kg/ha). The experiment comprised ten treatments, namely, pendimethalin 0.90 kg/ha as pre-emergence (PRE) + hand weeding (HW) at 45 DAS, oxadiargyl 75 g/ha as early post-emergence (POE) at 7 DAS + HW at 45 DAS, glyphosate 1.0 kg/ha as early POE at 7 DAS + HW at 45 DAS, pendimethalin 0.90 kg/ha as PRE + quizalofop-ethyl 40 g/ha POE at 45 DAS, pendimethalin 0.90 kg/ha as PRE + fenoxaprop-ethyl 75 g/ha POE at 45 DAS, pendimethalin 0.90 kg/ha as PRE + propaquizafop 75 g/ha as POE at 45 DAS, pendimethalin0.90 kg/ha as PRE + oxadiargyl 75 g/ha as POE at 45 DAS, HW twice at 15 and 45 DAS, weed free and unweeded check. The fennel variety '*GF-11*' was sown in second week of November at a spacing of 60 × 20 cm using seed rate of 8 kg/ha and fertilized with 90-30-00 kg N-P_2O_5-K_2O/ha.

Herbicides were uniformly applied with a spray volume 500 L/ha. Weed index (WI), weed control efficiency (WCE) and herbicidal efficiency index (HEI) were also worked out as per formulae to assess the efficiency of different weed management practices. For the study of weed seed bank, five soil samples were taken from the soil before sowing of the crop and one composite sample was prepared, while plot-wise samples were taken after harvest of the crop. The soil samples were drawn by core sampler of 2 cm in diameter from 15 cm depth as per the FAO protocol (Forcella *et al.* 2011). Each soil core was individually bagged and numbered. Seed extraction was done by sieving of the samples through copper sieves of 5 mm in diameter. This followed by their rinsing by water and sieving of the samples through a descending series of sieves up to sieve of 0.5 mm in diameter. Seeds were then dried at the room temperature and separated manually. Determination of the separated seeds was performed visually and sample-wise seed count was recorded.The experimental data recorded for growth parameters, yield attributes and yield parameters and economics were statistically analyzed for level of significance..

The experimental field was infested with monocot weeds, *viz. Brachiaria* sp. (7.67%), *Indigoflora glandulosa* (7.00%), *Asphodelus tenuifolius* (5.00%) and *Dactyloctenium aegyptium* (1.33%), dicot weeds, *viz. Digera arvensis* (18.67%), *Chenopodium album* L. (16.3%), *Physalis minima* (7.67%), *Portulaca oleracea* L. (5.67%), *Euphorbia hirta* (4.00%) and *Leucas aspera* (1.33%), and sedge *Cyperus rotundus* (25.3%).

Besides, in weed free treatment, the lowest weed population (Table 2) and the highest WCE (93.63) was recorded in HW twice at 15 and 45 DAS, which re-

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main at par with pendimethalin as PRE + HW at 45 DAS and pendimethalin as PRE + fenoxaprop-ethyl POE at 45 DAS. These treatments attributed to the effective control of early as well as late flushes of weeds resulted lower weed biomass. Next to weed free, minimum WI (0.52%) was obtained with pendimethalin PRE + fenoxaprop-ethyl POE at 45 DAS, closely followed by pendimethalin PRE + HW at 45 DAS (0.91%). The result confirms the findings of Thakral *et al.* (1995), Meena and Mehta (2009) and Nagar *et al*. (2009).

The dynamics of weed seed bank in soil drastically influenced by different weed management treatments (Table 1). The lowest weed seed bank was recorded with pendimethalin as PRE + HW. Pendimethalin as PRE controlled weeds right from the start and weeds those escaped and emerged later were controlled by hand weeding at 45 DAS. The treatments, *viz*. pendimethalin as PRE+ quizalofop-ethyl as POE, pendimethalin as PRE + fenoxaprop-ethyl as POE and pendimethalin as PRE + propaquizafop as POE were found to increase weed seed bank. This might be ascribed to the post-emergent herbicides, *viz*. quizalofop-ethyl, fenoxaprop-ethyl and propaquizafop which are grassy weed killers, leaving dicot weeds to produce seeds. The unweeded check recorded the highest size of weed seed bank due to production of large number of weed seeds under uncontrolled condition leading to 978 % increase in the initial weed seed bank.

Among the weed management, the highest plant height, and seed and stover yields (1.83 and 4.50 t/ha) were recorded with pendimethalin PRE + fenoxaprop-ethyl POE at 45 DAS, which was statistically at par with pendimethalin PRE + HW at 45 DAS and HW twice at 15 and 45 DAS (Table 1). The improved growth and yield under these treatments might be due to effective weed control resulting in lesser competition of weeds which might have resulted in the better utilization of nutrients and moisture available in the soil by crop leading to increased rate of photosynthesis and supply of photosynthates to various metabolic sinks. Similar findings have been reported by Bhati (1994), Chaudhary (2000), Meena and Mehta (2009) and Nagar *et al*. (2009). It was evident that pendimethalin as PRE + fenoxaprop as POE gave the highest net return (` 81,993/ha) and B:C ratio (3.22), followed by pendimethalin as PRE + HW, HW twice and weed free treatment (Table 1). The lower net returns and B:C ratio in weed free might be due to more cost required to create weed free condition for entire period in the crop season.

It was concluded that effective management of weeds along with profitable seed yield and net returns of direct seeded *Rabi* fennel can be obtained with pendimethalin PRE + fenoxaprop-ethyl POE at 45 DAS and reduction in seed bank obtained with pendimethalin PRE + HW at 45 DAS or HW twice at 15 and 45 DAS or keeping the crop weed free throughout crop period according to availability of labour.

Table 1. Effect of treatments on plant height, yield, dry weight of weeds, weed index and weed control efficiency, weed seed bank and economics of fennel

Treatment	Plant height at harvest (cm)	Seed yield (t/ha)	Stover yield (t/ha)	Dry weight of weeds at harvest (t/ha)	WI (%)	WCI (%)	Weed seed bank/core			Cost of cultivation (x10^3 `/ha)	Net returns (x10^3 `/ha)	B : C ratio
							Initial	Final	Addition (+)/ Depletion (-)			
Pendimethalin + HW	146.3	1.82	4.44	0.08	0.91	93.3	210	74	-136 (-65)	36.88	81.44	3.21
Oxadiargyl + HW	130.9	1.04	2.94	0.24	43.2	81.0	210	147	-63 (-30)	36.98	31.62	1.86
Glyphosate + HW	127.7	1.08	2.99	0.28	41.0	77.4	210	161	-49 (-23)	36.40	34.72	1.95
Pendimethalin + quizalofop	137.1	1.32	3.66	0.49	28.2	60.4	210	278	+68 (+32)	36.74	49.84	2.36
Pendimethalin + fenoxaprop	149.9	1.83	4.50	0.20	0.52	84.3	210	242	+32 (+15)	36.88	81.99	3.22
Pendimethalin + propaquizafop	136.5	1.32	3.64	0.30	28.0	75.7	210	221	+11 (+5)	36.71	50.05	2.36
Pendimethalin + oxadiargyl	137.4	1.31	3.55	0.10	28.5	91.6	210	99	-111 (-53)	36.84	49.19	2.34
HW twice	146.6	1.79	4.49	0.08	2.28	93.6	210	125	-85 (-40)	36.61	80.30	3.19
Weed free	153.1	1.84	4.51	0.00	0.00	100	210	76	-134 (-64)	39.75	79.70	3.01
Unweeded check	126.6	0.92	2.66	1.25	49.9	0.00	210	2264	+2054 (+978)	33.60	26.98	1.80
LSD (P=0.05)	14.7	0.36	0.82	0.08	-	-	-	73	-	-	-	-

Table 2. Effect of integrated weed management on weed population in fennel

Treatment	Monocot weeds/m^2 at			Dicot weeds/m^2 at			Sedge weeds/m^2 at			Total weeds/m^2 at		
	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest	30 DAS	60 DAS	Harvest
Pendimethalin + HW	1.22 (1.00)	1.17 (1.00)	1.05 (0.67)	2.27 (4.67)	1.34 (1.33)	1.44 (1.67)	2.60 (6.33)	1.56 (2.00)	1.66 (2.33)	3.53 (12.0)	2.18 (4.33)	2.22 (4.67)
Oxadiargyl + HW	1.34 (1.33)	1.68 (2.33)	1.77 (2.67)	2.38 (5.33)	2.54 (6.00)	2.40 (5.33)	3.27 (10.3)	2.67 (6.67)	2.68 (6.67)	4.14 (17.0)	3.94 (15.0)	3.89 (14.6)
Glyphosate + HW	1.86 (3.00)	1.84 (3.00)	1.56 (2.00)	4.22 (17.3)	2.57 (6.67)	2.59 (6.33)	2.53 (6.33)	2.18 (4.33)	2.78 (7.33)	5.21 (26.6)	3.79 (14.0)	4.02 (15.6)
Pendimethalin + quizalofop-ethyl	1.46 (1.67)	2.60 (6.33)	2.61 (6.33)	2.66 (6.67)	3.67 (13.0)	3.39 (11.0)	3.36 (11.0)	3.76 (13.7)	3.52 (12.00)	4.44 (19.3)	5.78 (33.0)	5.45 (29.3)
Pendimethalin + fenoxaprop-ethyl	1.34 (1.33)	1.22 (1.00)	1.17 (1.00)	2.65 (6.67)	3.58 (12.3)	3.13 (9.33)	2.67 (6.67)	1.58 (2.00)	1.72 (2.67)	3.89 (14.6)	3.98 (15.3)	3.67 (13.0)
Pendimethalin + propaquizafop	1.46 (1.67)	2.04 (3.67)	1.74 (2.67)	2.54 (6.00)	3.76 (13.6)	3.52 (12.0)	3.22 (10.0)	2.95 (8.33)	2.72 (7.00)	4.26 (17.7)	5.10 (25.6)	4.69 (21.6)
Pendimethalin + oxadiargyl	1.34 (1.33)	2.08 (4.00)	1.68 (2.33)	2.81 (7.67)	0.88 (0.33)	1.05 (0.67)	3.13 (9.33)	2.85 (7.67)	2.80 (7.33)	4.33 (18.3)	3.53 (12.0)	3.29 (10.3)
HW twice	1.05 (0.67)	1.22 (1.00)	1.17 (1.00)	1.34 (1.33)	1.34 (1.33)	1.44 (1.67)	1.34 (1.33)	1.34 (1.33)	1.68 (2.33)	1.95 (3.33)	2.04 (3.67)	2.33 (5.00)
Weed free	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.71 (0)	0.88 (0.33)	0.71 (0)	0.88 (0.33)	1.17 (1.00)	0.71 (0)	0.88 (0.33)	1.34 (1.33)
Unweeded check	2.78 (7.33)	4.41 (19.0)	4.63 (21.0)	5.95 (35.3)	7.26 (52.3)	7.33 (53.7)	4.03 (16.0)	4.93 (24.6)	5.04 (25.3)	7.67 (58.6)	9.82 (96.0)	10.02 (100)
LSD (P=0.05)	0.41	0.52	0.51	0.73	0.71	0.67	0.77	0.71	0.72	0.69	0.50	0.45

Figures in parentheses are original values of weed count $\sqrt{x+0.5}$ transformation

SUMMARY

A field experiment was conducted during *Rabi* season of 2011-12 at Junagadh (Gujarat) to find out most effective and economical method of weed control in *Rabi* fennel (*Foeniculum vulgare*). Results revealed that besides weed free treatment, significantly higher plant height, seed and stover yields of fennel were recorded with pre-emergence application of pendimethalin at 0.90 kg/ha + post-emergence application of fenoxaprop-ethyl at 75 g/ha at 45 DAS, which was at par with pendimethalin at 0.90 kg/ha PRE + hand weeding (HW) at 45 DAS and HW twice at 15 and 45 DAS. These treatments also recorded lower weed density and dry weight of weeds along with higher net returns and B:C ratio owing to lower weed index and higher weed control efficiency. The highest depletion of weed seed bank was observed with pendimethalin at 0.90 kg/ha PRE + HW at 45 DAS.

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